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(21) International Application Number: PCT/DK99/00105 (22) International Filing Date: 3 March 1999 (03.03.99) (30) Priority Data: 0280/98 3 March 1998 (03.03.98) DK (71) Applicant (for all designated States except US): DPL INDUSTRI APS [DK/DK]; Linde Allé 25, DK-2850 Nærum (DK). (72) Inventor; and (75) Inventor/Applicant (for US only): ANDREASEN, Knud [DK/DK]; Alfred Christensens Vej 11, DK-2820 Nærum (DK). (74) Agents: SCHØNNING, Søren et al.; International Patent-Bureau, Høje Taastrup Boulevard 23, DK-2630 Taastrup (DK).		(81) Designated States: AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>In English translation (filed in Danish).</i>
(54) Title: METHOD AND APPARATUS FOR PRINTING ON A STEPWISE FED WEB WITH A PRINTING INK, WHICH IS ACTIVATED BY RADIATION WITH LIGHT, PREFERABLY UV-LIGHT		
(57) Abstract <p>A method for printing with printing inks, the curing of which is activated by radiation with light, preferably UV light, and in which web with printing ink is advanced stepwise, and in which, above the printing ink, at least one light source is provided in a light unit, said light source being positioned in the travelling direction of the web after the printing process. In view of eliminating border marks with lustreless print which occur where the border between lighted and not yet lighted web with printing ink has been stagnant relative to the light source, the method comprises providing the light source with means, by means of which the upstream border of the lighted area, seen in the travelling direction of the web with the printing ink, is displaceable, and that these means are activated for displacement of this border in a direction opposite the travelling direction in periods, in which the web with the printing ink is stationary relative to the light unit.</p>		

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METHOD AND APPARATUS FOR PRINTING ON A STEPWISE FED WEB
WITH A PRINTING INK, WHICH IS ACTIVATED BY RADIATION
WITH LIGHT, PREFERABLY UV-LIGHT

5 The present invention relates to a method for
printing with printing inks, the curing of which is
activated by radiation with light, preferably UV light,
and in which a web with printing ink is advanced
stepwise, and in which, above the printing ink, at
10 least one light source is provided in a light unit,
said light source being positioned in the travelling
direction of the web after the printing process.
Moreover, the invention relates to an apparatus for
carrying out the method.

15 In printing processes, in which a particularly
lustrous or colour saturated print and a high degree of
edge definition are desired, it is common to use for
instance silk screen printing. In silk screen printing
the web with the printing ink will be moved stepwise,
20 the web being stationary for each print. Correspond-
ingly, the web will during the passage through the
light unit, in which the printing ink is cured by
radiation with UV light, be advanced stepwise. To avoid
a too strong heat influence, it is common to modulate
25 the light emission from the light sources, so that the
light emission during the stillstand of the web is
considerably reduced. Even though an effort is made to
minimize over or under exposure with light, it has been
a classic problem in respect of the printed matters
30 produced that so-called border marks occurred with a
mutual distance corresponding to the stepwise advanc-
ing. The border marks appear as areas in the print, in
which the surface lustre is less and in which the
surface in the worst cases has fine, closely packed
35 lines. No methods have been suggested to avoid such

border marks, and the efforts up till now have therefore aimed at designing the layout on the print in such a manner, that the border marks are placed in fields, where no printing is performed, or placed in areas, 5 where the cover surface is small and where the border marks consequently become less striking. The methods used up till now for eliminating border marks often entail an increased use of web with printing ink.

The object of the present invention is to completely eliminate the occurrence of border marks. The 10 invention resides in the realization that border marks occur in an area, where an initial curing has started, even though no exposure by light has taken place. In areas bordering the lighted areas, an uncontrolled 15 initial curing is apparently likely to occur solely on account of a chemical reaction. This initial curing changes the course of a subsequent curing by light.

The method according to the invention is characterized by the subject matter of claim 1.

20 By the method according to the invention the border of the area lighted with bigger or smaller light intensity will not at any time be stationary relative to the web with the printing ink, but care is taken that this border is still moving forwards, such that no 25 uncontrolled curing initiated on basis of the chemical conditions in the printing ink will take place. It has turned out that the speed and the regularity of the movement are critical to a smaller degree provided that the movement is constantly forward and the speed higher 30 than a certain minimum speed which applies to the printing ink in question. It is, of course, advantageous that the movement is regular and that the movability at disposal is distributed substantially over the whole period, in which the web with the 35 printing ink is stationary.

According to the invention, the period in which the web with the printing ink moves is utilized for taking the means for movement of the border of the light field upstream relative to the travelling direction back to the starting position. During this returning, the travelling speed should not be so big that the upstream light border moves backwards relative to the web with the printing ink or just becomes stationary. It is therefore preferable that the movement takes place at a suitable reduced speed.

The method may more concretely be carried out as stated in claims 4 or 5.

The apparatus according to the invention for printing with printing inks, the curing of which is activated by means of light radiation, preferably UV light, by use of the method according to claim 1, and which apparatus comprises means for applying a print to a web and means for stepwise feeding of the web provided with print through a light unit, in which the web passes an area lighted by a light source, is characterized in that the light source comprises means for making the upstream border of the lighted area, seen in the travelling direction of the web, movable relative to the web with the printing ink, which means comprise at least one of the following constructions:

- a movable diaphragm, which in active position partially covers the light opening of the light source,
- a displaceable securing of the light source,
- a tiltable securing of the light source,
- a fixedly secured diaphragm with a light shielding which is variable within different ranges, including a floating crystal diaphragm, preferably with effect suppressing filter.

In practice, very satisfactory results have been obtained with an apparatus comprising a movable dia-

phragm or tiltable light source, in which, according to the invention, the movable diaphragm or the movability of the light surface is controlled by means of a double-acting pneumatic cylinder with adjustable
5 suppression or controlled by means of an eccentric driven by a motor, for instance an electro motor with variable speed of rotation.

The invention will now be described in detail in the following with reference to the drawing, in which

10 Fig. 1 shows a printing process, in which the printing ink is cured by means of UV light,

Fig. 2 a UV light source with a diaphragm, by means of which the curing area of the light source is movable, and

15 Fig. 3 the light source according to Fig. 2 immediately before the movement of the diaphragm is finished.

In the printing process shown in Fig. 1, a web with printing ink 1 is advanced through a light unit 2
20 comprising a light source 3. In such a printing process, it is usual that the photoinitiators initiating the curing of the printing ink are in particular sensitive to UV light. The light source 3 is therefore provided with a UV light source connected to a vari-
25 able, electronic ballast which makes an exact adjustment of the light intensity possible and, if desired, also a modulation thereof.

In connection with for instance a silk printing process, which is used for obtaining a particularly
30 distinct and glossy print, the web with the printing ink will be advanced stepwise, the web with the printing being stationary each time the printing frame abuts it. At such a standstill of the web with the printing ink border marks occur - even though the light inten-
35 sity in the light source is reduced as much as possible

- said border marks appearing as areas or lines, in which the printing ink is less lustrous than in the remaining areas cured by normal light. In Fig. 1, the light field 4 of the light source is indicated. The border marks will typically occur along the light field 4 in the travelling direction of the upstream edge 5 of the web with the printing ink. The travelling direction of the web with the printing ink 1 is indicated by the arrow 6.

10 The object of the invention is to provide a method, in which the occurrence of border marks is eliminated. The method is founded on the fact that the light source is equipped with means which makes a constant movement possible, relative to the web with
15 the printing ink, of the upstream edge of the light field in a direction towards unlighted areas also in periods, during which the web with the printing ink is stationary. This movement is to take place, even though the light intensity in the border area is limited,
20 partly because in stationary periods it is necessary to suppress the light intensity in order not to overheat the web with the printing ink, partly because the light intensity in the border area is usually lower on account of the light distribution of the light source
25 which aims at focusing along a line. The good results obtained by the method lead to the conclusion that also in unlighted areas adjoining areas, in which a photo-initiation has occurred, a curing takes place which is purely chemically controlled and which develops irregu-
30 larly and uncontrollably resulting in impaired lustre and an anomalous structure characteristic of border marks. It is a fact that a subsequent, even strong light exposure is not able to remedy such an uncontrolled curing. The curing occurring in areas, which
35 border the areas exposed to light, is due to a chemical

reaction spreading into the ink not exposed. For a given printing ink, a speed, at which the reaction progresses, may be determined. For a given black test ink, the speed is found to be approx. 10 mm/sec.

5 Figs 2 and 3 show an embodiment of the practical use of the method. In Fig. 2 is shown how a diaphragm 7 is passed into the light beam from the light source 3. The diaphragm cuts off a section 8 of the lighted area. The position of the diaphragm in Fig. 2 corresponds to the starting position, when the movement of the web with the printing ink 1 is stopped. The movement of the web with the printing ink is continuously registered, either directly at the feeding means or by means of a tacho generator following the speed of the web with the printing ink. When a standstill is registered, a movement of the diaphragm is initiated, as indicated by the arrow 9. The movement is to be continuous and is preferably to take place at a constant speed and is to take place during the entire period, in which the web with the printing ink is stationary. Fig. 3. shows the position of the diaphragm immediately before the web with the printing ink is once more put into motion. In the period, in which the web with the printing ink is moved, the diaphragm is to return to the position shown in Fig. 2. This movement must not take place momentarily, because if so there is a risk that the border of the lighted area on the web with the printing ink may become stationary relative to the web with the printing ink, which would result in the formation of border marks. According to a preferred embodiment, the diaphragm 7 is moved by means of an electro motor with adjustable dampening of both forward backwards travel. In this way, a suitable moving speed may be adjusted to any given printing process, said speed utilizing with a suitable safety margin the time

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intervals at disposal. Tests in practice have shown that if said basic conditions are met, there are comparatively wide tolerances for the adjustment of the movement of the diaphragm.

- 5 The method may moreover be carried out by means of a movable suspension of the light source which is then induced to perform a rhythmic movement corresponding to the movement of the diaphragm. An arrangement with a fixed diaphragm with variable light transmittance, for
10 instance by means of floating crystal, will have the same effect as the mechanically moved diaphragm and makes a purely electronic control of the covering possible.

Moreover, the invention comprises a printing
15 apparatus provided with a light unit with means for rhythmically moving the border of the lighted area, in which the curing of the printing ink is initiated.

P A T E N T C L A I M S

1. A method for printing with printing inks, the curing of which is activated by radiation with light, preferably UV light, and in which a web with printing
5 ink is advanced stepwise, and in which, above the printing ink, at least one light source is provided in a light unit, said light source being positioned in the travelling direction of the web after the printing process,
- 10 c h a r a c t e r i z e d in that the light source is provided with means, by means of which the upstream border of the lighted area, seen in the travelling direction of the web with the printing ink, is displaceable, and that these means are activated for
15 displacement of this border in a direction opposite the travelling direction in periods, in which the web with the printing ink is stationary relative to the light unit.
2. A method according to claim 1,
- 20 c h a r a c t e r i z e d in that the displacement is performed at a speed which relative to the web with the printing ink is bigger than a certain minimum speed which applies to the printing ink in question.
3. A method according to claim 1 or 2,
- 25 c h a r a c t e r i z e d in that the means for displacement of the upstream border of the lighted area are reversed in periods, in which the web with the printing ink is fed, but at such a reduced speed that the border is not at any time stationary or moving
30 oppositely relative to the printing ink.
4. A method according to claim 1, and in which the light source is stationary, c h a r a c t e r i z e d in that the means for displacement of the upstream border of the lighted area is a diaphragm which is
35 movable between a position, in which the outlet opening

of the light source is partially covered, and a position, in which the outlet opening is exposed, said diaphragm moving during the standstill of the web to a gradual exposure, whereas the diaphragm during the
5 feeding of the web with the printing ink is moved in the opposite direction to cover the outlet opening.

5. A method according to claim 1, in which the light source is movable, c h a r a c t e r i z e d in that the light source in periods, in which the web with
10 the printing ink is stationary, is moved or tilted, such that the lighted area is moved forwards relative to the light unit, and in periods, in which the web with the printing ink is advanced, the light source is moved or tilted in the same direction as the web with
15 the printing ink, but at a smaller speed.

6. An apparatus for printing with printing inks, the curing of which is activated by means of light radiation, preferably UV light, by use of the method according to claim 1, and which apparatus comprises
20 means for applying a print to a web and means for stepwise feeding of the web provided with print through a light unit, in which the web passes an area lighted by a light source, c h a r a c t e r i z e d in that the light source comprises means for making the
25 upstream border of the lighted area, seen in the travelling direction of the web, movable relative to the web with the printing ink, which means comprise at least one of the following constructions:

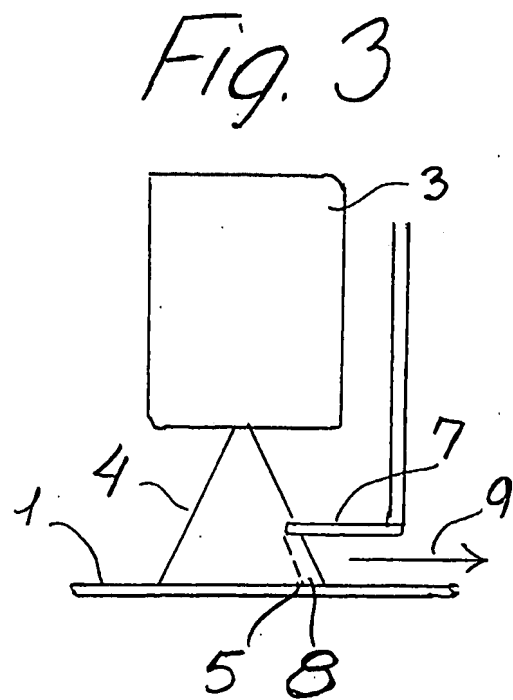
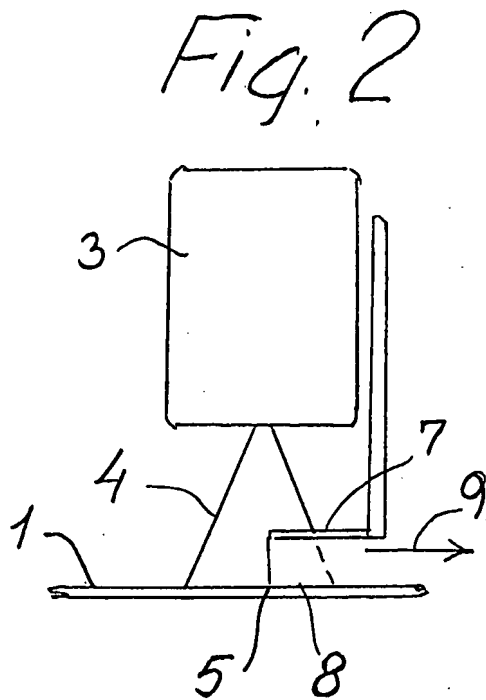
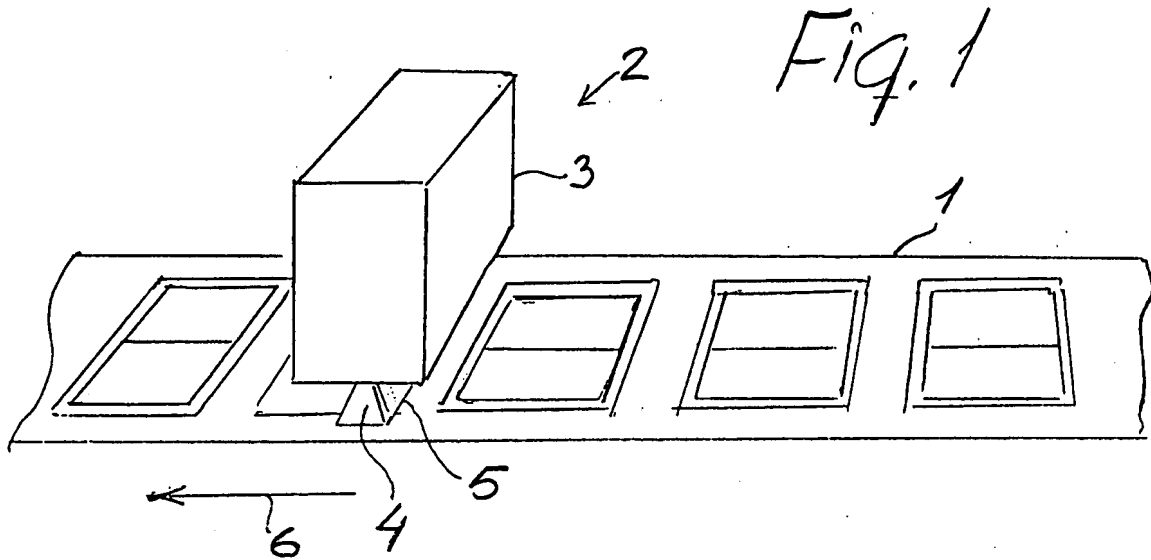
- a movable diaphragm, which in active position
30 partially covers the light opening of the light source,
- a displaceable securing of the light source,
- a tiltable securing of the light source,
- a fixedly secured diaphragm with a light shielding which is variable within different ranges, including a
35 floating crystal diaphragm, preferably with effect

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suppressing filter.

7. An apparatus according to claim 6,
c h a r a c t e r i z e d in that the movable dia-
phragm or the movability of the light source is guided
5 by means of an eccentric rotated by a motor, for
instance an electro motor with variable speed of
rotation.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 99/00105

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: B41F 23/04, B41F 15/12 // B41M 7/00, F26B 3/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: B41F, B41M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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WPI, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4408400 A (F. COLAPINTO), 11 October 1983 (11.10.83), column 1, line 29 - line 41; column 1, line 53 - column 2, line 22; column 2, line 56 - column 3, line 64, figures 1,2a-2 --	1-7
A	WO 9738276 A1 (RAE, M.C. ET AL), 16 October 1997 (16.10.97), page 1, paragraph 3 - page 2, paragraph 3, page 4, paragraph 5 - page 5 paragraph 2, figures) --	1-7
A	US 4864145 A (J.T. BURGIO, JR.), 5 Sept 1989 (05.09.89), column 3, line 9 - line 23; column 3, line 41 - column 4, line 1, figures 5-7, abstract --	1-7

☒ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5086700 A (E. VAN DEN BERG), 11 February 1992 (11.02.92), column 1, line 39 - column 2, line 7; column 2, line 33 - line 54; column 2, line 66 - column 3, line 24, figures 3,5-8 --	1-7
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Information on patent family members

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